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Improving the Properties of Carbon Steel Using Silication by Chemical Vapor Deposition (CVD)

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Abstract
The silication is one of the surface treatment technologies that can produce silic containing surface layers with high hardness, good corrosion, and wear resistance on the steel matrix.This study aims to add silica to the carbon steel used locally in the manufacture of some elements of the machines in a manner of CVD (deposition steam chemical) and to increase the hardness and stamina and resistance to shock and friction, also earning silica steel high resistance to corrosion and scratching, and soluble in acids, with the application of Asalkna for (2) hours at temperatures 565,1000,1100,1200 ºC, using ammonium chloride and ammonium fluoride in a mixture silication.Found that the proportion of silica formed on the surface of steel and its compounds are the best we can when the heat treatment of the degree of 1100ºC and use of fluoride of ammonium in a mixture Asalkna, and also increases hardness outer surface of the steel carbon and high summit of silica compared with the top of the iron in the case of sample treatment and the presence of the amount of very little silica compared with the high percentage of iron ore in the case of the sample; and the increasing rate of protection to the surface of the steel from corrosion at the same previous conditions.
Keywords: CVD - FeSi (chemical vapor deposited Silicon Iron)

1. Introduction

The longevity of the metal piece and make it resistant to corrosion as long as possible is one of the main goals of the heat treatment the surface, it has been in recent years, several research studies in this area in order to raise the corrosion resistance of steels and improve the mechanical properties are processors diffuse (Chemistry - thermal) of the methods used widely for this purpose, and is the most common the silication, carbonization, and Alentrdh ..... [1].

Use the silic with a number of metals to form compounds such as Mg_2Si and Ca_2Si; as used in this research silic iron is an alloy of Vero silica, are used in mining operations to adjust the proportion of silica in iron. I knew the process of chemical deposition from the gas phase (CVD) since the end of the last century and is based on a pilot boat of the metal to be deposited in contact with other gas near the surface so that the same chemical reaction gives raise at least a composite solid.

The process of chemical deposition from the gaseous phase is the result of several operations related to result from each other, namely:

a) the spread in the gas phase of the reactive materials around the sample to be covered.
b) adsorption of one or more of the gas on the sample surface to be covered.
c) a chemical reaction, the presence of nuclei and growth.

Of previous work

In 1993, the method of CVD for the deposition of a layer of metal niobium samples of copper and iron, and it returns PeCB niobium either hydrogen or steam zinc, as it was in this work to determine the conditions optimal for the best layer of protection and the status of the return on hydrogen, which led to the protection of samples of copper and iron from corrosion well [2].

Was also used chemical vapor deposition process for the deposition layer (double nuclei) of diamond and graphite surfaces using a gas activated by plasma or hot wire, or by using low pressure steam of hydrogen, which gives ample shipments of diamond nuclei of graphics [3.4 , 5,6,7].

My way is the use of the CVD and the ELID to refine surface mirrors and reduce Khcontha and make more precise and clear, and for the protection of iron alloy used for making wheels using carbide SiC and silica nitride [8-12].

The CVD method has used for the preparation of nano-channel distance ranging from 10 to 120nm of carbon materials of quartz and ceramics using plasma electromagnetic wave is very short for carbon hydride at 720ºC class existence a small amount of iron oxide [13.14].

Also studied the effect of temperature on the carbon steel used in buildings; it was found that temperature and other weather factors causing corrosion of steel, so the paint has been used to protect metals and other resistant to weather as almenyum and stainless steel [15].

In 2011 was the use of chemical vapor deposition method of metal organic compounds for the MOCVD annular Bntadinell allele on substrates of palladium and titanium silic at atmospheric pressure which led to the formation of very small clusters of palladium on silica surface and titanium [16].

2. The Importance of Research and Its Aims:

The addition of silica to the steel in a manner of CVD (deposition steam chemical) to increase the hardness and stamina and resistance to shock and friction, also earning silica steel high resistance to corrosion and scratching, and soluble in acids, so the aim of the research to the application of the method Asalkna on a steels commercial cheap used locally in the manufacture of some elements of the machines in order to raise its resistance to corrosion and improve the mechanical properties.

In conclusion it must be pointed out that there are a limited number of empirical studies in the longevity of the metal piece and make it resistant to corrosion as long as possible, but that's new in this research is the use of white sand located frequently in Syria in the process of deposition on carbon steel in a manner of CVD.

3.Experimental section:

3.1.The apparatus and tools used:

- X-ray X-ray of the company (PHILIPS) in the Department of Physics - Faculty of Science - University of the expedition.
- A device for measuring the hardness in the fertilizer factory - Homs.
- A spectral analysis of metals on the principle of optical spark electric version of the company Oxford Instruments in the Department of Physics - Faculty of Science - University of the expedition.
- A rectangular sheet of steel along the 5Cm and display 3Cm.
- Oven heat to the metal surface hardening of steels up to a temperature of 1200^{o}C in the Department of Chemistry - Faculty of Science - University of the expedition.
- Cylindrical chamber designed with dimensions suitable for the deposition of silica chemically.
- Silica dioxide SiO2 (white sand), which was obtained from the two villages.
- ammonium chloride and fluoride from the German company Merck.
- Vero silic which was obtained from the steel plant - Hama.

3.2.Testing:

3.2.1.Treatment of SiO_2:

Been clean white sand (SiO_2) of the impurities, then washed water and then adding hydrochloric acid center to get rid of stalagmites in it, was then washed with water several times, and dried at 60^{o}C for two hours, was to rid it of gravel using sieves electrical systems.

3.2.2.Treatment of samples of steel:

In this research the use of sheets of carbon steel rectangular dimensions 3×5Cm, which has been smoothing the surface with sandpaper.

3.2.3. Samples were divided by the treatment (The silication) into two groups:

Group A: heat-treated samples only.

Group B: Samples were in the process of gas silication Asalkna gas in the laboratories of the Faculty of Science, Ba'ath start of class until the class 565^{o}C 1200^{o}C for two hours.

3.2.4. The heat treatment Heat treatment program:

Treatment process was conducted by silic oven temperature up to a rate can be controlled, and controlled temperature and treatment time electronically, and are heated by electric coils.

Was prepared and the weight of a mixture silication on the balance of delicate mixture was divided into three groups according to the proportion of ammonium chloride and ammonium fluoride and mixture their according to the table (1) the following:

Table (1): shows the values of the weights of the materials used in the treatment

NH_4F Or NH_4Cl	Fe-Si	Sio_2	**Material**
20rg	2ogr	200gr	**Mass**
Merck Germany	Iron laboratory	Al kariatine	**Materials Source**

4.Results and discussion:

4.1.Test the hardness of the surface of carbon steel used:

After silication the carbon steel and the heating in an oven at temperatures ranging between (665-1200)° C for a period of 2 hours, where the following reactions occur:

$$NH_4Cl \rightarrow NH_3 + HCl \ldots\ldots\ldots\ldots\ldots(1)$$
$$2NH_3 \rightarrow N_2 + 3H_2 \ldots\ldots\ldots\ldots\ldots(2)$$
$$2HCl + Si \rightarrow SiCl_2 + H_2 \ldots\ldots\ldots(3)$$
$$SiCl_2 + Fe \rightarrow FeCl_2 + Si \ldots\ldots\ldots(4)$$
$$SiCl_2 + H_2 \rightarrow 2HCl + Si \ldots\ldots\ldots(5)$$

The reactions (1) and (2) occur in temperatures between 335-400° C, while two reactions (4) and (5) occur at a temperature treatment.

Been tested hardness of the surface of steel by the way Vickers, and was to reach the following results:

4.1.1. Determine the hardness of carbon steel when thermally treated in the case of non-use of a combination silication (users) for 120 minutes according to the table (2) the following:

table (2)

Hardness Vickers **HV_{Max}**	**Temperature(^oC)**	**Material**
370	1000	**Stander**
355	1100	
255	1200	

4.1.2.the case of the use of ammonium fluoride in a mixture silication at a different temperature and time of 120 minutes: the hardness values obtain of the surface carbon steel in accordance with the table (3) the following

table (3)

Hardness Vickers HV_{Max}	**Temperature (^oC)**	**Material**
155	565	NH_4F
410	1000	
980	1100	
860	1200	

4.1.3.in the case of the use of ammonium chloride in a mixture silication at different temperatures and time of 120 minutes: it get the results according to the following table (4):

table (4)

Hardness Vickers HV_{Max}	**Temperature(^oC)**	**Material**
205	565	NH_4Cl
280	1000	
660	1100	
635	1200	

Figure (1) Planning graph of the values of surface hardness at temperatures 1000, 1100, 1200 ^oC where we note that when using ammonium fluoride in a mixture silication was to get the best hardness of the surface of carbon steel when the temperature 1100^oC.

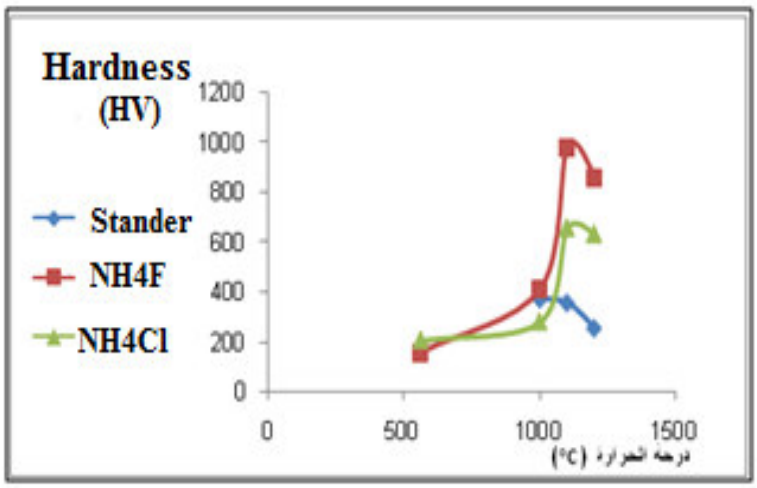


Figure (1)

4.2.Test deposition of silica on the surface of carbon steel:

Use the X-ray diffraction in order to verify the deposition of silica and its compounds on the surface of carbon steel after heat treatment for two hours, it reached to the results recorded in Table (5), compared with a bank of information.

Table (5)

Fe_2O_3	FeF_2	Fe_3Si	$FeSi_2$	FeSi	Si	Time hour)(	Temperature (°C)	Conditions
+	-	-	+	-	-	2	565	**20g NH_4Cl + 20g FeSi**
-	-	-	-	-	+	2	1100	
-	-	+	-	+	-	2	1150	
-	-	+	+	+	+	2	1200	
-	-	+	+	+	+	2	1100	**20g NH_4F + 20g FeSi**
-	-	+	+	+	+	2	1050	
-	-	+	+	+	-	2	1150	
-	-	-	-	-	+	2	1200	
+	-	-	-	-	-	2	1100	**Sample of ore**
+	-	-	-	-	-	2	1150	
+	-	-	-	-	-	2	1200	
-	+	+	+	+	+	2	1000	**15g NH_4Cl+ 5g NH_4F+ 20g FeSi**

The intensity was calculated for each spectrum of the samples according to the previous tables (6), (7) of the following:

Table (6)

intensity	Temperature (°C)	Material name
1400	1100	NH_4Cl
400	1150	
250	1200	

Table (7)

intensity	Temperature (°C)	Material name
1863	1100	NH_4F
388	1150	
1063	1200	

Note from the previous tables: that the intensity achieved at the highest temperature 1100°C and use of ammonium fluoride was also a silic and its compounds, but when using ammonium chloride constitute only silic.

4.3.Determine the percentage of silic deposited on the surface of carbon steel:

Determine the percentage of silic deposited on the surface of carbon steel, used analysis of electric spark, without specifying the type of compound formed as shown in the table (8) the following:

table (8)

the percentage of silic (%)	Temperature (°C)	Conditions
1.5	1000	**20g NH_4Cl + 20g FeSi**
1.5	1100	
1.5	1200	
6.5	1000	**20g NH_4F + 20g FeSi**
6.5	1100	
6.5	1200	
0.2819	1000	**15g NH_4Cl+ 5g NH_4F+ 20g FeSi**
0.2819	1100	
0.2819	1200	
0.127	1000	**Sample of ore**
0.166	1100	
0.275	1200	

Figure (2) planning chart for the proportion of silic and its compounds in the carbon steel at temperatures 1000, 1100, 1200 ° C when using each of the fluoride ammonium and chloride ammonium and mixture their a mixture silication; it obtained the highest percentage when you use a fluoride of ammonium in a mixture silication.

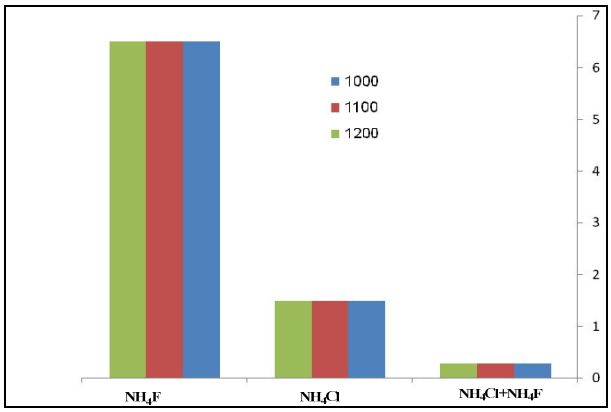


Figure (2)

As a result, we find that the interaction is at a higher temperature of 1000ºC, the highest of 0.6TF, where TF represents the melting point of iron, which is equal to 1539ºC

Found that the account: TF is equal to approximately 920ºC, where it cannot be spread silic or any other material at a temperature of less than 0.6TF, and that fluoride is more effective than ammonium chloride,as materials are referenced for oxide silic (white sand).

4.4.Study the surface of carbon steel using the electron microscope technology:

To study the surface properties of carbon steel used electron microscope technology for the first sample of ore samples and the other after treatment. Figure (3) microscope image scanner to the surface of the sample iron ore; it shows the lack of pores and grain size is a regular, clear and shows nice unit of X-Ray associated with a microscope on the existence of the amount of very little silica compared with the rate of iron high (Figure 4):

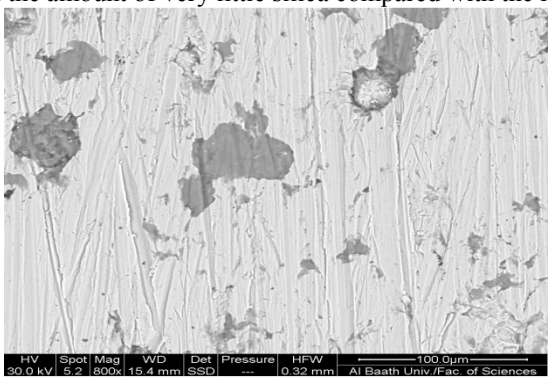


Figure (3)

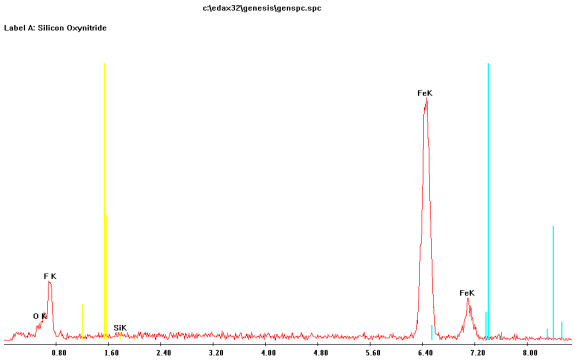
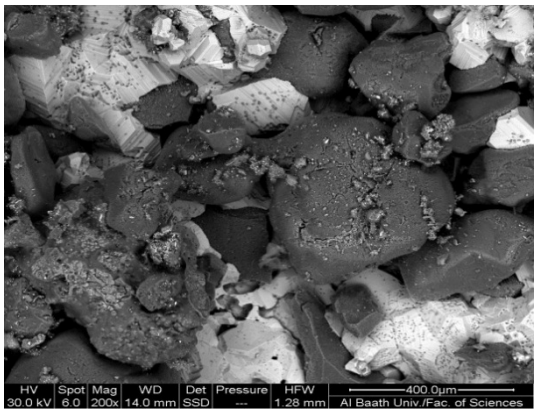
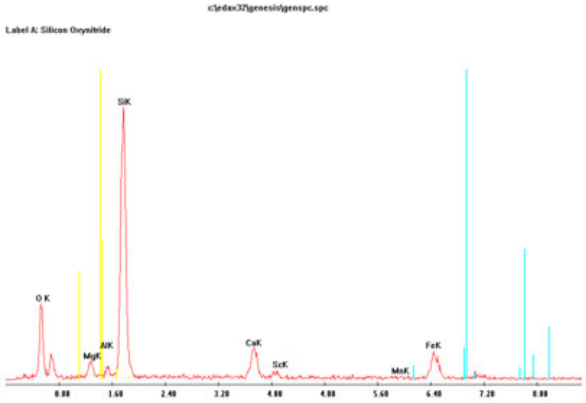


Figure (4)

The form (5) shows the microscope image scanner to the surface of a sample of iron earlier after treatment accumulation of silic by the presence of fluoride of ammonium and catalytic Ferro silica when class 1100ºC; which indicate the presence of pores and clear as a result of interactions returned to the oxide Silic on the surface of carbon steel and ranges average grain size between 100-200µm, and demonstrates the unity of the spectrum of X-Ray microscope associated with the high summit of silica compared with the top of the iron (Figure 6), and this is consistent with the results of a X-Ray diffraction.



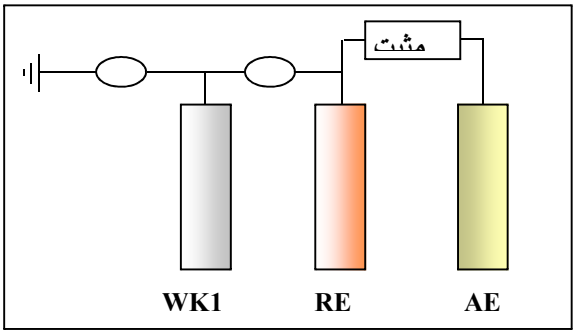
Figure(5)



Figure(6)

4.5.Study the resistance of the surface of carbon steel corrosion in the middle of the sea water:
Device was used to determine the speed corrosion-mail form (Gill AC) which is based method of assessing the electrochemical corrosion by measuring the intensity of erosive power and then calculate the corrosion rate of one (mm / year).

The conduct of the test
We conducted tests using the device described as follows:

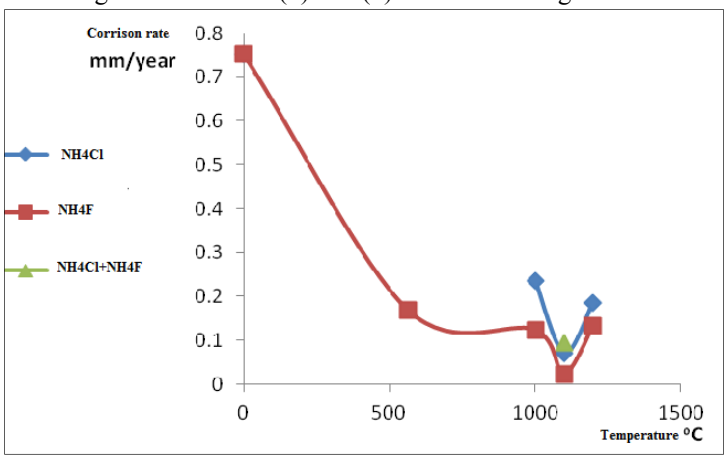


Preparation of samples of steel in the manner already mentioned.
• Prepare a solution of sea water concentration of 30% (30g salt per liter of sea water) required for each experiment.
• Develop and Reference Assistant poles and pole operation represented by the alloy studied in the solution prepared after taking into account the development of these poles is facing one in the solution as possible.
• Connect these electrodes as required to form the electrochemical cell.
• testing to determine the speed by a corrosion-mail and using the custom, which gives us the power curve with voltage (after introduction of the necessary data such as the type and the alloy chemical composition and dimensions, intensity and duration of the test ....).
• We recorded the corrosion valuies rate and the speed of corrosion of carbon steel samples untreated and treatment at different temperatures according to (Table 9) the following:

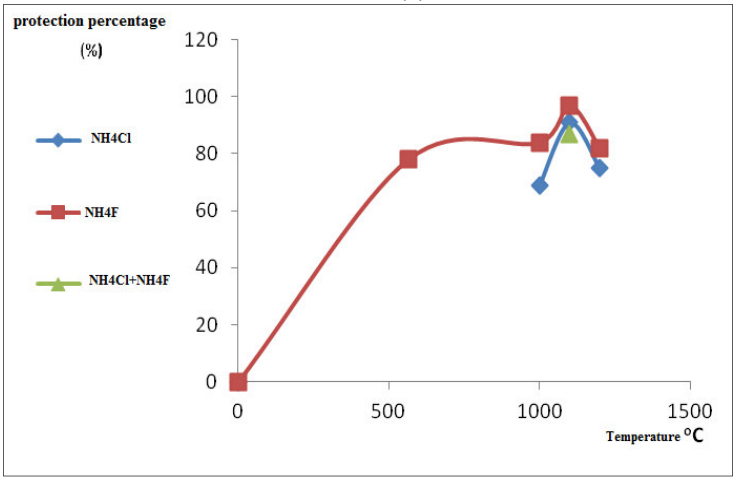
Table (9)

Protection Percentage (%)	(mm/year) corrosion Rate	Temperature (°C)	Conditions
0	0.7538	-	**Sample of ore**
69	0.2354	1000	**20g NH_4Cl+ 20g FeSi**
91	0.0716	1100	
75	0.1853	1200	
78	0.1687	565	**20g NH_4F+ 20g FeSi**
84	0.1240	1000	
97	0.0235	1100	
82	0.1324	1200	
87	0.0946	1100	**15g NH_4Cl+ 5g NH_4F+ 20g FeSi**

And the design of the relationship between each of the rate of corrosion and protection percentage in indices of temperature according to the schemes (7) and (8) of the following:



Scheme (7)



Scheme (8)

Note from the previous schemes: that when you deal with carbon steel using a fluoride ammonium or chloride ammonium or mixture their as are referenced when the temperature 1100°C down rapid erosion of its surface is large and increases its resistance to corrosion in the middle of the sea water, especially when you use a fluoride ammonium as is referenced to the deposition of silica on the surface of carbon steel ; as a silic layers on the surface of carbon steel substantial protection to surface from corrosion, and has a protection rate of 97% when treated with ammonium fluoride.

Summary and Conclusions:

1.The increase in temperature of treatment and the use of NH_4Cl in a mixture silication lead to an increase in the

proportion of silic deposited only on the surface of steel.
2. The increase in temperature of treatment and the use of NH_4F in a mixture silication lead to an increase in the proportion of silic and its compounds are deployed within the carbon steel.
3. The silication of carbon steel have increased the value of hardness at the surface temperature 1100°C using ammonium fluoride as a silic oxide are referenced to the better use of ammonium chloride, and this severely increase the surface leads to an increase in wear-resistant steel.
4. We propose to move the experimental results obtained in this study to the practice, in collaboration with universities in the country, research centers, companies, public and private sector.
5. Further studies and research in this area on some types of metals as steel non rust types.
6. Used the technology electron microscope for two samples of steel carbon first sample of ore and the other after treatment with fluoride of ammonium when the temperature 1100°C; as it was noted the high summit of silic compared with the top of the iron in the case of sample treatment and the presence of the amount of very little silica compared with the rate of iron high in the case of the sample raw .
7. The process of silication carbon steel to increase the security of the surface of the steel from corrosion at ambient temperature 1100°C using ammonium fluoride as a silica oxide are referenced to the better use of ammonium chloride, and this increase leads to an increase in wear-resistant steel.

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